
The Simulator for Training Policemen to Perform their Duties at the Scene of a Road Accident

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Abstract:

Purpose: The article presents the main design and construction assumptions of the simulator. It is a new generation simulator that allows for a radical increase in the effectiveness and efficiency of training policemen. Road safety is an important sphere for public life. One of the elements influencing the level of safety is lighting of vehicles, which was the subject of the analysis.

Design/Methodology/Approach: The research was carried out by problem analysis and their synthesis. The research project consisting in constructing and then building a modern simulator using advanced technologies of immersion in virtual reality to train policemen in the field of conducting activities at the scene of a road accident.

Findings: The conducted analysis highlighted the enormous potential related to the impact of vehicle lighting on traffic safety. The obtained results of research and construction allow for effective and extremely detailed training of policemen, which so far could not be achieved with traditional teaching methods.

Practical Implications: The problems described in the article may contribute to increasing awareness of the impact of lighting on road safety. The multi-variant nature of the training profiles significantly increases the qualifications and skills of police officers. The use of advanced artificial intelligence algorithms allows us to eliminate even the smallest shortcomings that were almost impossible to detect by the instructors conducting practical classes in the previous training system.

Originality: The article deals with issues and the sphere of public and economic life that are not discussed so often in scientific literature.

Keywords: Safety, road traffic, vehicle.

JEL codes: Safety issues.

Paper type: Research paper.

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1. Introduction

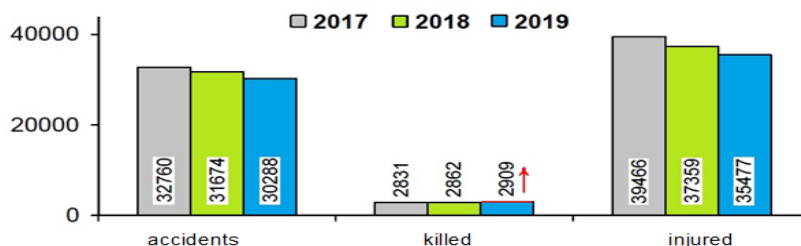
It is a truism to say that many road users are killed or injured on our roads. One of the characteristics of modern society is the increase in mobility and the unprecedented increase in the number of motor vehicles (both single and two-track). Accident statistics indicate with greater or lesser fluctuation that continuous improvement of all services guarding life, health and property is necessary. In 2019, 30,288 road accidents taking place on public roads, in residential or traffic zones were reported to the Police (Collective work, 2019). Compared to the year: 2017 – when there were 32,760 accidents, the number decreased by 2,472 – which constituted a reduction by 7.5%; 2018 – when there were 31,674 accidents, the number decreased by 1,386 – which constituted a reduction by 4.4%.

Unfortunately, as a result of these accidents, 2,909 people died – which compared to the year: 2017 – is an increase by 78 people (+2.8%); 2018 – is an increase by 47 people (+1.6%). In the same year, 2019, 455,454 road collisions were reported to Police units – an annual increase of over 4% (E. Symon, 2020). Each road incident requires documentation (depending on its complexity...) to be prepared by a patrol or patrols dispatched by the officer on duty (Ordinance No. 30, 2017). Statistically, the highest number of accidents and incidents occurs in June, October and September. The high number of accidents in the autumn months is probably due to worsening weather conditions, and thus also road conditions. On the other hand, during the summer, there is an increase in traffic due to holiday trips and returns (Ristvej, 2020). The social and economic costs associated with accident victims (serious injuries and fatalities) are enormous. According to the Report of the Polish Chamber of Insurance, e.g., in 2015, they were estimated at about PLN 50 billion, which corresponded to about 3% of the GDP. The scale of burden on the economy is illustrated by examples of possible – alternative use of this amount:

- Construction of 500 km of motorways;
- Provision for nearly 6 years of functioning of the police;
- Provision for a year and a half of functioning of hospitals;
- etc.

Another PLN 9 billion of losses resulting from material damage should be added to this (Coll. Works, 2019).

Figure 1. *Quantitative summary of road accidents in the last three years*

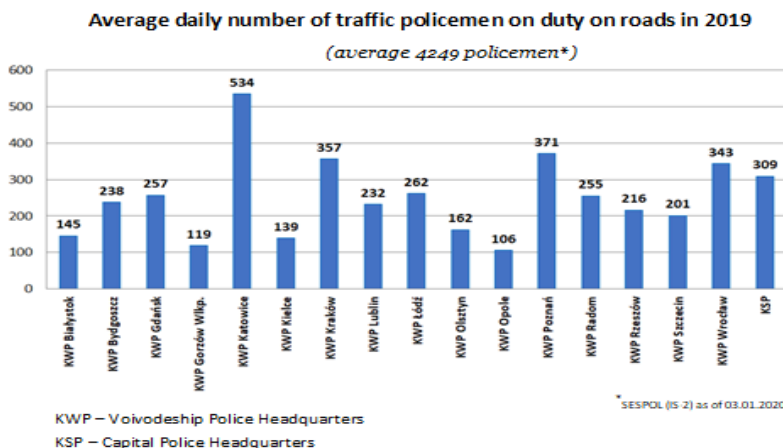


Source: Based on E. Symon, 2020.

The 2013-2020 programme did not fully achieve its objectives in terms of improving security. Therefore, it seems justified to develop and implement a (new) Road Traffic Safety Improvement Programme for 2021-2030.

Identification and conceptualization of prevention and intervention projects clearly indicates the high level of involvement of road traffic officers in activities related to ensuring road safety. The scope of activity on the road is very wide – however, the effectiveness and efficiency, to a great extent, depend on the individual preparation, training and predisposition of policemen. Support for the teaching activities is to be provided by the simulator, which is the subject of this project.

Figure 2. Summary of road traffic officers' involvement in field activities on the roads



Source: Own study.

2. Policemen's Work at the Scene of a Road Incident – Outline of the Issue of Didactic and Technical Considerations

Many services and businesses, as well as specialist companies, operate and interact with each other at the scene of a road incident. Each of them performs its specialist tasks with different intensity, depending on the circumstances and time. Statistical data indicate that quite often a police patrol is the first to arrive at the scene of a road

incident and its officers take the first rescue and security measures. Until the arrival of specialist services (emergency medical services, the fire brigade, etc.), police officers are obliged to provide first aid and ensure the safety of victims and other road users (Perkins, 2015). Therefore, the high level of preparation and training of traffic officers is extremely important. During in-service training courses policemen receive specialist knowledge and acquire skills under the supervision of experienced teaching and instructing staff.

Unfortunately, however, the disadvantage of such a training system is the lack of comprehensive instructor's supervision over all training nuances, starting with medical rescue operations and ending with securing traces and evidence, aimed at explaining all circumstances of the event (Ukrainski, 1992; Kaminski, 2013). This is, among other things, directly related to the so-called insurance crime – in 2018 alone, more than 12 thousand cases of compensation and benefits fraud in the amount of over PLN 230 million were detected. The vast majority of cases – thanks to properly prepared accident documentation – can be detected already at the stage of the attempted crime. Precision and accuracy of all activities on the incident site is the basis for subsequent legal and financial investigations (Reza, 2011).

The dynamic development of modern information technologies that we have observed in recent years and the widespread access to computer programs create an opportunity to support various types of training using computer simulation devices. Initially, computers had too little computing power to be able to simulate various phenomena, e.g. driving vehicles in a more or less realistic way. As information technology develops, new opportunities have emerged. Initially, these were simple programs with two-dimensional graphics, which over time evolved into spatial simulators, faithfully reflecting a real-life situation. Training experience in the aviation, navy and many other technical fields clearly shows the real benefits of implementing simulation systems. Not only does this involve a drastic reduction in costs, but many of them offer the opportunity to fully monitor the training process and eliminate almost all shortcomings.

3. Research Methodology

The main objective of the project “Simulator supporting the training of policemen in the implementation of activities on the scene of a road accident” is to build a simulator enabling the acquisition of practical skills to conduct activities on the scene of a road accident along with technical and utility documentation. The simulator is an effective tool enabling the training of policemen of road traffic cells to perform activities on the spot of typical and unusual road incidents, such as mass accidents, traffic disasters or other crisis situations. The simulator effectively connects the virtual world with the real world, i.e., transfers the trainee to the virtual world (visualization of the scene of the incident), while allowing the performance of official activities at the scene of the incident (inspection of the scene, documentation

of activities, first aid to victims of road accidents, etc.). The detailed objectives of the project include:

- Development of a terrain database module.
- Development of an object database module, including experimentally validated models of the dynamics of a passenger car, delivery truck, truck, bus, and tanker.
- Development of a measuring module.
- Development of a documentation module.
- Development of the projection module.
- Development of a sub-play module taking into account all possible road events with the use of the terrain base constructed and simulated vehicles and objects – typical road events (collision, accident) and unusual events (including emergency events such as mass accidents, land traffic disasters).
- Development of a training program for traffic policemen based on the simulator built and conducting the training in the Police training unit (evaluation of the training program and simulator in real conditions).
- Development of a module responsible for the implementation of a set of 3 rescue and training phantoms in the didactic process.
- Development of a communication module using the HLA architecture to enable connection of the system with the National Simulation Platform of Crisis Management Entities.
- Development of a training and risk analysis module enabling more effective validation of officers' activities in the training system.

In order to achieve the assumed goal of the project, due to the multidimensionality of the issue, it was necessary to use complementary research methods and techniques. Such an approach allowed us to obtain the assumed result of the research in the form of a complete picture of the analyzed issue. In order to implement the adopted research assumptions, both theoretical and empirical methods as well as techniques and tools adapted to them were used. The methods used include: the method of content analysis and comparative analysis based on the qualitative analysis of the content or functionality contained in documents, as well as ordering and interpretation of the content in terms of the research purpose. The subject literature, scientific studies, domestic and foreign publications, materials from online collections, and normative acts related to the thematic area of the project were analyzed.

The study also covered source materials concerning the use of training simulators by the police for preventive activities, as well as the functional and operational specification of the existing simulation and training solutions, with particular emphasis on national solutions. The aim of the research was to select the optimal existing simulation solutions, on which laboratory tests of the components of the modules of the simulation system could be carried out. In this method, it is

recommended to eliminate the beliefs and expectations of the researcher, hence the research techniques in the analysis of interactions often consist of making tests based on checklists. The tests used functional tests based on lists with guidelines to assess to what extent the tested system meets the requirements specified in the project.

Inspection consisting of a visual examination of the device, including its mechanical structure (hardware), software documentation, and/or other data, allowing to confirm compliance with the checked requirement. Visual verification consists of inspecting the actual installation, examining drawings showing physical dependencies, and/or documents confirming compliance with the requirements. The purpose of the inspection is also to confirm that the manufactured equipment complies with the approved documentation in accordance with which it was designed, built, and tested. The components of the test object have been tested in order to confirm their compliance with the requirements of the Technical Specification. All moving parts have been tested to find that they function smoothly and at the same time meet the accuracy requirements specified in the Technical Specification. This study was conducted prior to controlled observation.

Controlled observation consisting of the systematic recording of behaviors occurring during a simulation study (Action Demonstration) according to a previously assumed scenario. Compliance with the requirements was checked by a demonstration of operation prepared by the Contractor, which took place during the control tests. During the demonstration, the ability of the device to function in typical or “worst-case scenarios” cases was demonstrated. The quantitative and qualitative characteristics of the device were verified by performing specific tasks, usually involving the use of subsystems in a certain way, and comparing the results with the initial functional, operational, and technical requirements. A research tool in the form of a questionnaire was used for the observation.

The project used the experience, knowledge, and skills gained by the consortium participants in the previously implemented projects entitled “Integrated Simulation Platform of Crisis Management Entities” (no. DOBRBIO4-041-13177-2013, “Construction of a prototype simulator of Police operations in crisis situations” (no. OR00004107), “Construction of a police prototype of a multifunctional mobile command post” (no. OR00000111), “Steering simulator privileged vehicles during typical and extreme operations” (no. O ROB 0011 01/ID/11/1), “Virtual system for improving the tactics of intervention activities of services responsible for safety and shooting training” (no. DOB-BIO7/19/01/2015).

The quality of the content-related implementation in the scientific area related to road safety was ensured by the Police Academy in Szczytno and the Main School of Fire Service in Warsaw. These units have unquestionable experience in constructing and conducting training for officers performing tasks in the field of road traffic. The competencies of the Police Academy in Szczytno in the field of training Police officers on road safety and securing the scene of a road accident are especially

valuable. The indicated competencies were used primarily in the course of research and development works related, in particular, to demonstration and testing.

The key to the success of the project within the assumed deadline is the fact that the company ETC-PZL, as a manufacturer of simulators, has advanced models that have been validated experimentally, e.g., passenger vehicle, truck, bus, and tanker (which, however, need to be checked) made for the needs of commercial systems offered to customers around the world, as well as very good knowledge of the technologies and software used in them. The indicated models were brought to the project as the entrepreneur's own contribution. The company also has a proprietary simulation engine and terrain database, which were used as input elements for the work in the project. As a result of the research and design work carried out, a fully functional simulation system demonstrator was created, providing the basis for the development of a scientific report.

4. The “SymZdaDrog” Simulator – The concept, Development History, Significance to the Training Process

The subject of the “SymZdaDrog” Project is the design and manufacture of an educational and training device which is part of a priority technological area – modern technologies and innovative solutions in the field of detecting, combating and neutralizing threats as well as specialist forensic techniques, defined for the 7th strategic direction of scientific research and development works National security and defence, decreed in the National Research Programme (NRP). The implementation of the project results has contributed significantly to increasing the operational capacity of the services responsible for security and combating crime. The project assumptions are very closely related to:

- 1) The “Efficient State Strategy 2013-2020”;
- 2) The Strategy of Development of the National Security System of the Republic of Poland 2012 – 2022;
- 3) The National Development Strategy 2020, i.e., strategic area I, in particular the consolidation of national security;
- 4) The EUROPE 2020 strategy (Strategy for smart, sustainable and inclusive growth), i.e., improving the conditions for research and development and raising education levels;
- 5) The OECD Innovation Strategy by supporting science and new technological solutions that can contribute to economic development and employment growth;
- 6) The long-term national development strategy “Poland 2030. The third wave of modernity”, which emphasizes simultaneous development in three strategic areas, competitiveness and innovation of the economy, balancing the development potential of Polish regions and the efficiency and effectiveness of the state;

- 7) The National Strategy of Regional Development 2010-20: Regions, Cities, Rural Areas, which puts emphasis on the objectives and the manner of operation of public entities, in particular the government and voivodeship self-governments in relation to Polish space to achieve the strategic objectives of national development including the effective use of specific regional and territorial development potential;
- 8) The Transport Development Strategy to 2020, which indicates strategic directions in the area of road safety, including safe vehicles, safe behaviour of traffic participants;
- 9) The Development Strategy of the Police Academy in Szczytno for the years 2018- 2021 adopted by Resolution No. 143/III/2017 of the Senate of the Police Academy in Szczytno dated December 22, 2017, which includes the mission of the Academy and the priority area – scientific research and the Academy’s relations with the social and economic environment.

The scope of knowledge and solutions developed within the project can be described as specialist modules:

- ✓ Terrain database module;
- ✓ Object database module;
- ✓ Experimentally validated vehicle dynamics models;
- ✓ Measurement module;
- ✓ Projection module;
- ✓ Hitch module.

Terrain database module: Containing diverse terrain: highly urbanized (city centre), suburban and industrial, high-mountain (roads with different gradients - long ascents and descents and switchbacks), motorways, expressways, single and dual carriageways, roads with paved and unpaved surface. Simulated roads very effectively reflect the elements of real roads in accordance with the conditions specified in the Act of March 21, 1985 on Public Roads (Journal of Laws of 2016, item 1440) along with other road elements (specified in the executive regulations) such as roadsides, pavements, crossings, railroad tracks, traffic signs and marks and traffic lights, other elements of traffic management.

The object database module allows you to simulate the behaviour of road users, such as passenger cars, trucks, and tractors, with semi-trailers, special vehicles, agricultural tractors, buses, tankers, emergency vehicles, motorcycles, trams, railway trains, cyclists, pedestrians, wild animals of different sizes, pets.

Experimentally validated vehicle dynamics models: passenger vehicles, delivery vans, trucks, buses and tankers.

Measurement module: It uses technology that allows to add to the simulation a real object (a tool, a measuring device used in the Police) held in the hand by a Police officer while handling a road incident.

Projection module: Research was conducted to select the optimal solutions in the field of video projection. A solution was chosen from among flat, spherical and cylindrical projection systems. Further tests were conducted to determine the parameters of the subsystem so as to eliminate or minimize the likelihood of disease in the simulation participants.

Hitch module: It takes into account possible road events with the use of a ready-made field database and simulation of vehicles and objects - ordinary road events (collisions, accidents) and unusual events (e.g., crisis events, such as mass accidents, land traffic crashes). The simulator also allows you to edit documents of the road accident site preservation on the basis of documents (protocols) prepared by policemen.

The system demonstrator - the elements of which became part of the prototype, and then - the created and practically tested demonstrator - consists of a computer (control module) and a standard projection system (VR google) with a running track (Figure 3). It made it possible to demonstrate all the key elements of the technology being built, i.e. the database, objects, models, and the current GUI version. An important element of the didactic support for both instructors and trainees is the system manual, which contains guidelines and standards for simulator training.

An integral part of the simulator, apart from the typical technical scope, is the first aid training module. According to the provisions of the Ordinance of the Chief Police Commander - ... a policeman who arrives at the scene of the traffic incident, pursuant to § 29. 1.3) *provides first aid to the injured person...* (Ordinance No. 30, 2017). The implementation of this provision has also been reflected in the Project implementation schedule. Although, in accordance with Article 24 sec. 1 of the Act on the State Medical Rescue Service (Journal of Laws, 2017, item 2195), the average commuting time from the call to the arrival of the emergency medical team in cities is from 8 to 15 minutes, while in rural areas it is 15-20 minutes – practice and experience related to road accidents clearly indicate that often the police patrol arrives first (Journal of Laws, 2017; van Alem, 2003; Weisfeldt, 2019).

5. The Role of the “SymZdaDrog” Project in the Implementation of Training Courses for Police Officers in Carrying out Activities at the Scene of a Road Incident

The simulator is a useful tool to support the training of policemen in the implementation of activities on the scene of a road accident. It is a highly effective device, with the help of which a properly prepared instructor efficiently trains and improves the skills of course participants (during practical classes on the preparatory

course and/or on the advance course) of traffic policemen. This device prepares well for performing activities on the site of a road accident - both ordinary and unusual - (e.g., the nature of the damming up or even a mass event) (Paliska, 2011; Zhang, 2016; 2020). The range of variants that can be simulated covers all road events, including collisions, accidents, mass events, land disasters, or other emergencies.

The simulator allows a kind of connection between the virtual world and the real world. Using appropriate technical devices, e.g., a platform for movement (walking) coupled with VR (Virtual Reality) goggles, transporting the trainee into the virtual world—the visualized incident location. This device enables comprehensive performance of official activities at the scene of the road incident, i.e., inspection of the scene of the incident, documenting the activities, first aid to the injured in a road incident, etc. - in accordance with the provisions of the Order of the Police Commander in Chief on the performance of road duties (Ordinance No. 30, 2017). Success in project implementation requires having (or creating) many advanced and unique technologies from the area of simulation and simulator applications. These mainly include the following:

- Technologies related to the modelling of artificial intelligence, i.a., algorithms of people's behavior and movement (starting with individuals, through groups of people, individual rescue teams or close-ranked police and military units, and ending with crowds of many thousands), algorithms of car traffic in metropolitan conditions and of vehicles in off-road conditions.
- Technologies related to effective rendering of 3D scenes, depiction of crowds, static and dynamic 3D objects and special effects (fires, explosions, smoke, etc.
- Technologies related to the linking of aerial and terrestrial visualization, i.a. the integration of raster and vector terrain databases.
- Technologies related to the effective exchange of information between different simulators (the international HLA standard).
- Technologies specified in points "1-3" were mainly used in the tasks carried out in the second stage. Technologies identified in point "4" - in stage III.

The project used the competences gained by the consortium participants in the previously implemented projects. The quality of content, especially in the scientific field related to road safety, was ensured by the Police Academy in Szczytno and the Main School of Fire Service in Warsaw. Knowledge, skills and, above all, experience were used primarily during the implementation of stages I-V and at the stages of development related to demonstration and testing in conditions similar to real and real ones. The key to the success of the project, within the time limit set by the ordering party, is the fact that ETC-PZL, as a manufacturer of simulators, has advanced, experimentally validated models of, i.a., passenger vehicles, trucks, buses and tankers (which, however, need to be checked), as well as very good knowledge of the technologies and software used in them.

The functionality of the first aid training is carried out with the help of rescue and training dummies that have different capabilities and represent people of different ages with various injuries and dysfunctions. The dummies selected for research are:

- ✓ Baby Anne;
- ✓ Resusci Junior;
- ✓ Little Anne;
- ✓ Resusci Anne – a dummy with the SimPad Skill Reporter;
- ✓ Resusci Anne – a dummy with the Skill Reporter (slightly older model than the one above).

The methodology of preliminary (qualification and selection) tests consisted in checking and learning all the implemented possibilities for a selected dummy test group. Their application potential was divided into two groups: physical capabilities and IT capabilities. The research programme included practical training with the use of all specified rescue and training dummies. Medical procedures were carried out according to the rules presented in the pamphlets on qualified first aid for National Firefighting and Rescue System (Chomonic, 2019).

The dummies selected for research reflect the human being at different times of biological development (age). The aim of this selection was to conduct research on the full range of dummies and to apply as many procedures and scenarios as possible – according to unified criteria and scope. Dummies have been selected for testing, which have different technical and didactic capabilities and can be integrated with IT systems. Universal dummies and dummies useful for potential implementation in the “SymZdaDrog” simulator were sought. The tests started with the dummy with the trade name *Baby Anne*. It is a dummy infant and is produced by Laerdal.

The training dummy is used to teach cardiopulmonary resuscitation (CPR) in infants. The dummy reflects the typical physiognomy and physiology of a 3-month-old infant. It is easy to disassemble and reassemble. Apart from CPR, airway obstruction and foreign body removal can be simulated on the dummy. The dummy has realistic facial features and a movable lower mandible. The chest rises during artificial respiration (the I see-hear-feel principle). The fact that chest compression faithfully reflects the force to be applied during CPR also adds to the realism of the training. An unquestionable advantage of the dummy is its interchangeable parts, including facial parts and respiratory tract elements.

The *Resusci Junior* is a training dummy that imitates a child of about 8 years of age. The dummy presents the full figure of a boy. It can also be used for water rescue exercises. The dummy on which the tests were performed was equipped with the Resusci Baby – Resusci Junior SkillGuide™ device. This device allows you to monitor the correctness of breathing, respiratory tract unblocking, correct hand positioning and the depth and frequency of compressions. An unquestionable

advantage of the dummy is the correctly reproduced anatomical structure. This allows to find the right point for chest compressions. This undoubtedly increases the degree of realism of the conducted training. In addition, it is possible to simulate respiratory tract obstruction. To make it easier to unblock it, one should tilt the head back or suitably extend the movable mandible. The dummy can be powered from either a battery or from the mains. Replacement parts are available, including replaceable respiratory tract and facial parts. The set includes a training mat and a transport bag.

The *Little Anne* dummy is one of the most popular training dummies used during CPR training — it imitates an adult (limited to the torso). This dummy can be used with a training automatic external defibrillator. The dummy is in line with the latest European Resuscitation Council guidelines from 2015. It allows for full replacement of the fastest wearing parts, i.e.: the lungs, face, respiratory tract and ribs. The dummy is also equipped with an acoustic signaling system (click-clack). The system can be switched on and off using a special tie rod. Thanks to this solution, the student and the instructor are informed about how deeply the chest is compressed. If the pressure is too low, you will not hear a 'click'. However, when the compressions are performed correctly, i.e. when the chest is pressed to a depth of about 5-6 cm, a characteristic click can be heard each time.

Resusci Anne (tested version with the SimPad) is a new edition of dummies produced in several versions. The technologically advanced SP version was used for the tests – i.e. a torso with the functionality of instrumental respiratory tract unblocking techniques (e.g., an incubation tube). This dummy has implemented solutions that enable tracking of CPR parameters. After the training is finished, the information is stored in the device memory. Trained rescuer is evaluated at the end of the exercise on the basis of feedback from the application.

Resusci Anne version with SkillReporter® is a dummy on which BLS (Basic Life Support) training is possible⁶. With this device it is possible to keep track of some of the CPR parameters, such as the location of the hands, the depth of compressions, the unblocking of the respiratory tract and the amount of air supplied to the lungs. The device is equipped with a metronome, which can beat a rhythm of 80 or 100 beats per minute. It also has the ability to store CPR data in external memory.

6. Technologies Used to Develop the Simulator

The technology of augmented virtual reality (AVR) that we present in this project goes far beyond previous experience. It allows us to easily assimilate and consolidate knowledge as well as to digitally “participate” in the created environment of a road incident – stroll around it, explore it, and even shape it. It also allows mapping virtual content in the surrounding reality of the road situation,

⁶*Definition: a set of activities including the maintenance of respiratory tract patency and the maintenance of breathing and circulation without the use of any instruments.*

measuring deformations in vehicle bodies resulting from collisions with other objects, and interacting with a digitally generated 3D image.

For proper analysis of road accidents, it is important to properly assess the type and structure of car deformation based on the size of the vehicle (body) deformation. The density of deformation grids (in the mapping of analytical algorithms) enables precise mapping of vehicle damage in order to, for instance, reconstruct a real road accident in given conditions and circumstances. Special program modules enable the implementation of the scratch and deformation editor. They rely on the use of mechanisms friendly to 2D user interfaces in a 3D environment, taking into account the irregular shapes of the terrain mapping database in 3D geometry.

Many years of experience in handling road incidents indicate a large extent of collisions, accidents and disasters. Some traffic incidents may have traces and evidence spread over several hundred meters, and sometimes even several kilometres. In the case of multi-vehicle collisions or disasters in land traffic on expressways and/or motorways, it happens that vehicle fragments can also be found outside the road lane (Kaminski, 2013). Therefore, the problem arose of creating an effective didactic tool combining all elements of the real world with the world of augmented virtual reality. In order to solve this problem the design team decided to combine the OMNI treadmill (used in the most modern and technologically advanced computer games) and AVR goggles. This configuration solves several seemingly difficult issues.

First of all, the quality of 3D image presentation is very good. Some problems occur with small traces (but these are clearly visible on the monitors). The combination of treadmill and goggles allows the police officer to virtually move around and perform actions at the scene of the event over a distance of several hundred or more meters. Restrictions on movement of the training person and wearing goggles are not a big discomfort, but the reality of the activities performed is very high. What is more, it would be difficult to find a training room with parameters similar to reality on a 1:1 scale (traffic incident service operating on several hundred meters). For smooth and trouble-free operation of the AVR system, apart from computer equipment, three basic components are necessary:

1. an Omni set containing the treadmill and its accessories;
2. HTC Vive goggles set;
3. large-display monitor system of the documentation preparation module.

The Omni treadmill is the most important component of the entire AVR set. It is a controller that allows natural movement in the world of AVR. The user steps inside the treadmill and can run on it, and their movements are transferred to the virtual training space. Trained officers can move forward, backward, and turn around at any angle. The treadmill is characterized by a very durable construction, adapted for use at mass events, or in stationary facilities such as VR salons or amusement parks,

where people of various physiques can come and use it. Its innovation is the lack of moving parts that can be easily damaged – a solid and durable treadmill surface combined with a rigid and structurally durable hip band guarantee that the equipment will function even under heavy load and high intensity. It is also worth emphasizing that the intensity and rapidity of movements during the training of policemen is much lower than the participants of dynamic computer games. The treadmill is made of hard, durable plastic, and its curved shape allows the trainee to move more naturally. As with normal walking, during walking in Omni treadmill we put the weight of our body on the forward leg, which causes the foot to slip by itself on the treadmill mat, imitating natural gait. The treadmill is technologically adapted to support people with a height of 140 to 195 cm and a weight of up to 130 kg. By using the treadmill, you can move without restrictions by walking or running in the available virtual environment. The treadmill does not support the function of jumping and crouching – in order to provide the stability and safety of the user.

Allowing this type of manoeuvres would require increasing the number of moving parts of the treadmill and thus reduced support for people who run inside it. According to the manufacturer's assurances, dynamic walking as well as running on the treadmill is completely safe, because the treadmill is equipped with a hip belt that helps maintain body stability and balance in situations of dynamic turns and changes in the user's direction of movement. In order to conduct research on the visualization system based on VR goggles, the research environment (dynamic module) was integrated with the documentation workstation (static module). The training participant can move in virtual reality using the Omni treadmill and the HTC Vive Pro VR headset. The concept of the dynamic module is shown in Figure 3.

Figure 3. An overview of the dynamic module



Source: Courtesy of Cyberith GmbH.

The synchronization of the image presented on the screens with the HTC Vive Pro goggles and Omni treadmill was correct. The treadmill and goggles have their

limitations, but their precise hardware integration allows us to state that the treadmill in combination with goggles allows you to perform all activities at the scene of a road accident, in particular in situations where the traces of the event will require a dozen, several dozen or even several hundred meters of displacement in the virtual space of the trainee in order to e.g. inspect the place of the event. One of the restrictions on goggles is the data transmission cable, because wireless transmission does not provide image transmission in real time, which could translate into the emergence of simulation disease syndromes. The support stand visible on the right (Figure 3) supports the goggles' wiring and does not restrict the movement of the arms or the twisting of cables around the body of the trainee. The user has to wear special shoes while using the Omni treadmill, which necessitates disinfecting them before and after each exercise.

Moving on a treadmill, i.e., moving around in the virtual world requires short-term preparatory and adaptive training, allowing the trained person to synchronize the movements of their own body with the image seen in goggles. It should be emphasized that the movement or change of direction (turning) of the exerciser takes place on a limited space of the treadmill and basically in one place. The simulated movement consists in the slipping of the feet of the trainee using appropriate footwear on the base of the treadmill. Due to slight discrepancies between the physiological movement during walking (natural way of movement) and the limitations of the dimensions of the dynamic platform – the trainee must properly synchronize the “new” way of moving in virtual reality. Vertical stability of the trainee is ensured by a lap belt installed in the omnidirectional handle.

The next, essential training element of the “SymZdaDrog” simulator is the static documentation module. It is intended for the implementation of the last training element which is documenting the place of a road accident. The use of screen monitors with a large diagonal and FHD resolution allows the trainee to notice even the smallest traces and details, which are sometimes very important to reconstruct the course of a road incident. These screens are also used to summarize the training, indicate errors, pay attention to the details of a traffic incident or the location of the traces. Flat screens may not reflect the depth of the scene as well as cylindrical or spherical screens, but in the simulator the reality of the tasks performed is ensured by goggles. VR goggles are mainly used in computer games and simulators to move on a relatively small area, usually up to several square meters.

Documentation module is a separate computer station equipped with a standard PC (laptop) and a desktop computer with a large-screen display that allows you to view all elements of the implemented variant (scenario) exercised by a trained police officer. It is a tool for precise preview of the activities carried out and collecting data documentation (i.e., traces, parameters and process evidence). A set of relevant documents has been developed to document a collision or accident site. It is an open set of documents that can be edited, modified and supplemented during training. This solution allows the trainee to precisely fill in the document card, which is also

a summary of their activity on the site of a “virtual road incident”. The use of such an educational model gives many training profits related to precision, meticulousness and shaping perceptiveness (Radun, 2009).

7. Summary and Conclusions

Based on a literature and bibliographic review as well as knowledge gained during conferences, symposia and specialist fairs (ITEC, GAMBIT, etc.). The solutions and functionalities proposed in this Project allow for comprehensive preparation of Police officers for comprehensive collection of evidence and performing procedural activities at the scene of a road accident. The few training aids found in the literature descriptions usually have limited functionality and a very diffused training realism associated with many simplifications and didactic compromises. Practical field training, internships in field units, tutorials⁷ and other forms of coaching and in-service training of traffic policemen are long and expensive. Their effectiveness undoubtedly improved after reaching the technological level assumed in the Project.

The introduction of the “SymZdaDrog” simulator to the police training system significantly lowered the training costs. Training of people using the simulator eliminates material costs and reduces the risk of loss of life and health as a result of actions taken by insufficiently qualified trainees. Another advantage of using the simulator is the possibility to conduct research to assess the impact of factors that may affect the quality of road accident service. Thanks to the applied mathematical models and simulation procedures, the reaction of the verification system of artificial intelligence algorithms to decisions made by students is immediate and adequate to the situation. The implementation of such a tool in the police training system could help to improve the quality of training for police officers and may have a positive impact on many organizational and legal aspects. The added value of the Project is the ability to use the simulator to develop and optimize universal - model procedures for policemen performing tasks at the scene of a road accident and to facilitate more effective use of their potential.

Another element contributing to its importance is the possibility to assess the impact of external factors on the speed and quality of officers’ actions in difficult situations. It also enables professional training of policemen prepared to handle road incidents in various environmental and climatic conditions (also taking into account the risks associated with the transport of hazardous materials under ADR regulations). The use of the “SymZdaDrog” simulator allows for multiple repetitions of exercises in various variants, thanks to which officers are better prepared to perform specific

⁷ A new form of training – consisting in practice “under the watchful eye” of an experienced officer (tutor) – *Tutoring* is a modern didactic method, particularly effective in developing the potential of students (officers, course participants, trainees) and motivating them to work independently and self-develop.

tasks, creating a potential of knowledge and experience in many fields, exceeding the possibilities of traditional training.

The undoubted added value of the Project is also the implementation of the rescue phantoms module for learning and improving first aid. This functionality will allow to expand the group of people who will be able to save lives on and off duty.

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